A Test Bed for Hybrid Broadcast Broadband Services

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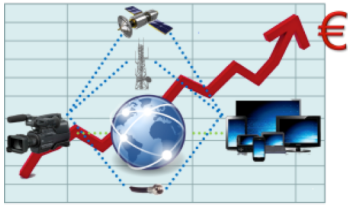
Abstract
The users' demand for more content with more features have made broadcaster worldwide investigate how to enhance their broadcast services while not overloading their bandwidth capacities. This paper presents various use cases and a technical framework for experimenting with hybrid broadcast broadband delivery. This test bed can be reproduced from scratch using open source tools.

Author Keywords
Hybrid Delivery; Broadcast; Broadband; Synchronization; Accessibility; Scalability; HEVC.

ACM Classification Keywords
H.5.1. Information interfaces and presentation: Multimedia Information Systems: Video.

Introduction
Recent years have seen the increasing presence of connected devices in the home network, from mobile phones to tablets, and finally including set-top-boxes and TV sets as well. Content distribution on these devices is fairly complex: some devices are HD capable, others can reach UHD, some are 3DTV or multichannel audio capable, and some are not interaction friendly! Additionally, users expect more from their TV shows than ever: non-linear access to services, supplemental

The H2B2VS project aims at investigating the hybrid distribution of TV programs and services over Broadcast and Broadband networks.



The project is structured along three main topics:

- Hybrid Broadcast Broadband architecture and use case definition,
- Impact of the hybrid distribution on future technologies,
- Demonstrators

http://h2b2vs.epfl.ch/

content enhancement (alternate view, subtitles, synchronized meta-data feeds) or accessibility enhancements for impaired users. In order to not saturate the broadcast network with all possible variations of the content, synchronized usage of broadband links carrying additional services is worth considering. In this paper, we present the work that is being conducted within the H2B2VS project on this area, together with an open test bed for hybrid services.

Related Works

The broadcast industry has long been looking for efficient synchronization of broadcast and broadband content. Many broadcast/broadband applications currently deployed rely on audio fingerprinting or watermarking to recover the source media timeline at the receiver device. While this technology works relatively well [1], it suffers from a number of deployment drawbacks (continuous audio recording, energy efficiency, synchronization accuracy, service deployment scalability…). The DVB group has proposed the possibility to stream a timeline along with the content, in a dedicated component of the multiplex [2], but this induces a large overhead (90 kbps for a 60 Hz video). To solve this issue, the MPEG and DVB-CSS groups have been collaborating on defining an extension to MPEG-2 TS called TEMI [3]. This extension enables tighter packing of media and associated data: for a 60 Hz video, the timeline signaling cost is reduced to 7 kbps.

Synchronization between devices has also been subject to many research and associated standards from IETF, DVB or OIPF. In this paper, we focus solely on inter-stream synchronization on a single device (TV), and will not cover multi-screen applications.

Use case reviews

Figure 1 illustrates some of these use cases studied by H2B2VS, and classified as follows.

Multi-layer Video Coding Quality Improvements:
Services offering spatial scalability from SD (resp. HD) to HD (resp. UHD), temporal scalability from 25/30 Hz to 50/60 up to 100/120 Hz, view scalability from single view to stereo or multi-view, color scalability from standard color gamut to High Dynamic Range or Wide Color Gamut.

Delivery Enhancements through broadband
Services such as catch-up, fast rewind and fast forward-to-live scenario, full service switchover or FEC repair from satellite to broadband in case of link loss, regional variation of national programs.

Content Personalization and Accessibility
Services with alternate subtitles for visually impaired viewers, alternative audio and sign language streams for hearing-impaired viewers, personalized advertisement through broadband splicing of the broadcast channel.

H2B2VS Test Bed

H2B2VS has been integrating the following technologies for its demonstrators: MPEG-2 Transport Stream for the historical TV broadcast with TEMI for timecode insertion, HEVC and its scalable extension (SHVC) standard for the video coding, and MPEG-DASH [4] for the transport of additional streams over broadband.

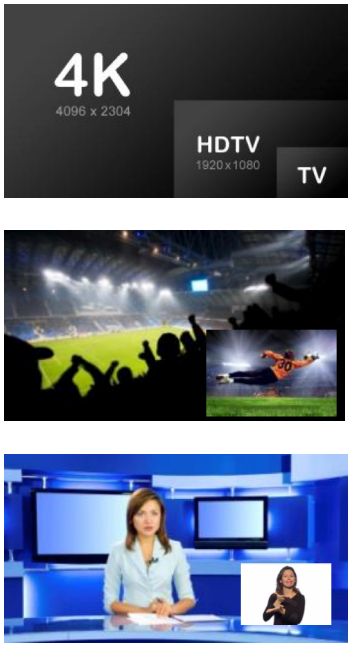


Figure 1 - Some H2B2VS Use Cases

Live feeds from one or two cameras are fed to real-time HEVC encoders, supporting both MPEG-2 TS with TEMI insertion output and DASH output using ISOBMFF [5] segments; the TEMI timecodes describe the media time in the current DASH period. In order to differentiate between the main content and the additional one, such as sign language or alternate audio streams, the Role descriptor of DASH is used.

The broadcast content is then fed to a link using either a test lab DVB-T2 setup or one of the DVB-T2 multiplexes aired in France. Broadband feed was then fed to a CDN for OTT distribution.

The player used is GPAC [6], with TEMI support integrated in the TS demultiplexer. The content synchronization is performed at the presentation level (i.e. after decoding) for most use cases.

Open-Source Test Bed

The test chain can be reproduced using the tools from the GPAC project, using pre-encoded content. All tools required for setting up the test bed are open-source, and a detailed overview of the setup is available at:

http://download.tsi.telecom-paristech.fr/gpac/demos_hybrid/

MPEG-2 TS Multiplexer

GPAC TS Multiplexer *MP42TS* has been updated to allow insertion of TEMI URLs and timecodes in a program of a transport stream. TEMI URLs rate insertion can be configured, while timecode injection is done for each frame of the video stream. The generated TS can be streamed through the network using multicast or unicast IP. The TEMI timecodes used are the presentation time of the source media, usually an ISOBMFF file. They can either loop when the source loops (used when the linked content is an ISOBMFF or a static MPEG-DASH session), or keep increasing (used when the linked content is a dynamic MPEG-DASH session).

MPEG-DASH Multiplexer

GPAC DASH Multiplexer *MP4Box* has since long the capability to produce both static and dynamic MPEG-DASH sessions; it also supports HEVC and Layered-HEVC packaging and DASH multiplexing. In order to allow scalable video in hybrid transport layers, *MP4Box* has the possibility to split the different HEVC layers in different tracks; the base layer track can then be fed to MP42TS for broadcast simulation, while the enhancement layer can be converted to a DASH session. The resulting session can then be distributed with any web server.

Session Playback

The session can be viewed by opening the multicast URL with the GPAC client (note that other clients may play the multicast only, without the broadband features). The GUI mode may be used for debugging purposes or to test the time shifting functionalities. In terms of architecture, the TEMI timecodes are used to position the playback of the DASH session. The timecode in a broadcast frame directly indicates the presentation time of the corresponding frame in the DASH period. For dynamic sessions, the DASH live edge is first resolved using the NTP clock, and it is currently assumed that both timelines are aligned, i.e. the player cannot implicitly seek to a point in the time shift buffer of the DASH session; this limitation is justified by the lack of use cases covering it, and that equivalent behavior may be achieved using static DASH sessions. For layered HEVC decoding, the time mapping is performed when entering the decoding buffer, and the

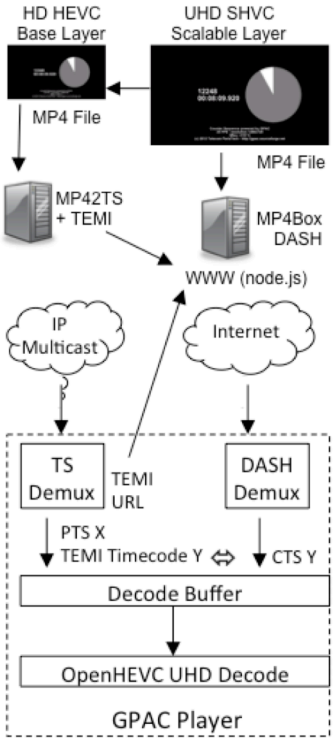


Figure 2 - Test Chain for Hybrid Scalable UHD

HEVC NALU units with the same timestamp from both broadcast and broadband are re-aggregated in a single buffer fed to the OpenHEVC decoder [7]. An example test chain is illustrated in Figure 2.

Results and Discussions

During our experiments, we observed a delay induced by the DVB-T2 chain of around 2 seconds. The delay observed on the CDN side was varying but reasonable, ranging from 50ms to 250 ms depending on the test location. The average GOP and segment duration used for the DASH encoder was set to 2 seconds, while the broadcast channel uses smaller GOP length (below one second). The player was configured to use a 3 seconds buffer at the MPEG-2 TS side. This gives the player enough time to fetch the DASH segments, while maintaining an overall delay acceptable for most demonstration purposes. We believe the platform should be able to cope with much lower buffering if low latency DASH techniques were to be used, such as HTTP1.1 chunk transfer. The GPAC framework already demonstrated DASH latencies below 300ms in local networks, and we plan to investigate these techniques in the context of hybrid delivery.

Conclusion

Hybrid content delivery is a key enabler for delivering network usage for the core content. Standard bodies such as MPEG, DVB or HbbTV have already developed technologies enabling use case presented here. In this paper, we have detailed an end-to-end setup for content delivery over hybrid broadcast broadband networks, and are providing a complete test chain to reproduce this setup. We hope academics and industrial research labs will further reuse this work. Our future work will focus on introducing low latency schemes in the platform to lower buffering constraints at the receiver side.

Acknowledgements

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